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IRRIGATION PRACTICE IN RICE GROWING.

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INTRODUCTION.

Irrigation is a necessity in profitable rice culture, except in favored localities whose seasonal rainfall is very high. In general, therefore, a plentiful and easily accessible water supply is the first requisite where rice is to be grown, and the proper utilization of this supply in irrigating the crop is a matter of much importance to the rice grower. It is the purpose of this bulletin to discuss methods and means of irrigation as developed in the rice fields of the United States.

Rice thrives best in a warm, humid climate. A growing season of at least 135 days and a rich loam or clay soil level enough to permit economical irrigation, underlain by a tight formation through which water will not percolate readily, are other conditions only second in importance to the water supply, if the crop is to be produced on a profitable scale. These combined conditions are found in various sections along the South Atlantic coast, on the prairies of southwestern Louisiana, southeastern Texas, eastern Arkansas, and the alluvial lands along the Mississippi River and its tributaries in those States and in Mississippi.

Almost the whole of the present rice crop of the United States is grown in the sections named, although rice fields now being developed in the Sacramento Valley of California may soon add a considerable area to the acreage devoted to this crop. For many years the Carolina rice fields produced nearly all of the rice grown in the United States, but the Civil War greatly injured the industry, and in recent years many of the Carolina farmers have found their crop unable to compete with rice grown on new lands farther west by cheaper methods. By far the larger part of the rice crop of the United States is now produced on the prairie lands of Louisiana, Texas, and Arkansas.

NOTE.—This bulletin will be of interest to farmers growing rice under irrigation.

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MAKING A WATER SUPPLY AVAILABLE.

Most of the rice land in the South Atlantic States lies along tide-water streams. It is very level, and at high tide is subject to overflow. To control this, levees are built along the river fronts and back to the high land, holding off the river water during high tide. Inside levees divide the fields into rectangular-shaped cuts, approximately 40 acres each in area. The water is brought to the field through a canal with branches extending to each cut. A small box, locally called a trunk, with a gate at either end, is placed under the levee where the branch enters, to regulate the flow of water to and from the field. A ditch about 4 feet wide and 4 feet deep extends from the trunk parallel to the levee which surrounds each cut and about 20 feet from it, around the inside of each cut and back to the trunk. Other narrower ditches extend in from the main ditch on opposite sides until only enough open space remains for a team to pass between their ends. This system of ditches permits the water to flow quickly to or from the cuts when the gates of the trunks are properly set, according to the height of the tide.

Much of the rice land along the Mississippi also is protected from the river's overflow by levees, since it is lower than the level of the water at certain stages of the river's flow. At such times water for irrigation is lifted from the river and over the levees by means of siphons. When the river is low the water must be pumped into reservoirs built inside the levee and enough higher than the field to cause the water to flow through the siphon and so over the levee. Small portable pumping plants are used for this purpose. During the seasons when the river is high the expense of obtaining water is low, but when the river is low the cost of irrigation becomes much heavier on account of the expense of pumping.

The fields along the lower Mississippi slope back to the swamp or low land. Parallel drain ditches are dug down this slope at distances apart varying from 200 to 600 feet. Levees are built along the sides of the ditches and cross levees to meet them at right angles, one for every drop of 0.2 to 0.5 foot in the slope of the land. The cross levees thus come 50 to 800 feet apart and form rectangular cuts of varying sizes. The water is allowed to flow from cut to cut across the field, and at the proper time is drained off through the ditches.

Rice growing has been somewhat stimulated in the upper part of the river country in recent years by the advance of the boll weevil into that section, and much land formerly devoted to the cultivation of cotton has been put into rice. In this section methods of irrigation are similar to those practiced on the prairie lands of Arkansas, southeastern Texas, and southwestern Louisiana. There a water supply is secured by pumping from rivers, lakes, and bayous, and from wells,

the latter permitting the irrigation of large areas not accessible to canals.

The industry is new in California, but promises to become of much importance in certain sections of that State, especially in the Sacramento Valley, where water is secured for irrigation by gravity flow or by pumping from streams.

PUMPING.

In the three principal rice-growing States—Louisiana, Texas, and Arkansas—all but 2.5 per cent of the irrigated land in rice is supplied with water by pumping, and wells afford a supply for about one-third of this area. These wells and their pumping equipment are usually owned by the individual farmers, and in all about one-half the rice acreage is now irrigated by means of works owned or controlled by the water users. The remainder of the rice land is irrigated with water obtained from large canals owned by companies or individuals, who furnish it to the rice growers on a rental basis.

The pumping plants vary in size and capacity according to the area to be irrigated and the height to which the water must be elevated. For prairie lands the machinery is generally designed to provide 7½ gallons, or 1 cubic foot, of water per minute for each acre irrigated. For the alluvial lands along the streams 10 gallons of water per minute per acre or more should be provided, and if the soil is a loose, sandy loam, with a porous subsoil, and is located near a river or lake, 38 to 40 gallons per minute per acre sometimes is required. If the water is not carried far and is economically applied to the fields, a smaller amount will be sufficient. It is not good policy to estimate too closely in designing a plant, and some plants now operating are capable of delivering much more water than is usually needed. The height to which water is elevated varies from 10 to 80 feet.

Some of the largest and best-equipped pumping plants in the world are located along the streams of southwestern Louisiana and southeastern Texas for use in rice irrigation. They are frequently equipped with one or more large horizontal centrifugal or rotary pumps operated by compound condensing Corliss engines. Steam is generally supplied from horizontal water-tube boilers, and petroleum is often used as fuel. A saving of about 10 per cent of the fuel is effected by the use of feed-water heaters. Among earlier pumping plants to be installed were many which delivered large quantities of water but were expensive to operate. High cost of operation was not then considered serious by many irrigators, but during recent years many improvements have been made in the design of plants which have appreciably lowered the expense of pumping. Petroleum

has been found to be the best fuel within short distances of the oil fields and most of the pumping plants in these sections use it. When wood and coal are plentiful and cheap they are used, especially for small outfits. In other locations gasoline and kerosene are used.

CANALS.

The canals which carry the water to the rice fields consist merely of two parallel levees built upon the surface of the ground 50 to 200 feet apart. Ordinarily the canals are given but little fall and the slow velocity at which the water flows results in almost no loss of head and keeps down the total lift at the pumping plant. This plan is essential, for the cost of pumping depends largely upon the height to which the water must be elevated. Laterals or smaller canals branch out from the main canal to reach land in each direction. Still smaller laterals distribute the water to the fields.

One of the chief items of cost in rice growing is the irrigation water. This varies with the height to which the water is pumped, the amount of water used, the cost of the fuel and attendance for the pumping plant, and the first cost and efficiency of the plant itself. A considerable saving can sometimes be made by several congenial farmers uniting in the establishment of one large plant for their common use, where numerous small individual outfits would otherwise be necessary. A saving in the first cost of machinery, in buying and handling fuel, repairs, and wages of engineers and firemen will thus be possible. One main canal of generous capacity will then answer the purpose of several smaller ones.

WELLS.

The development of wells has permitted the irrigation of much land that otherwise would not be planted to rice. Wells capable of supplying water for rice irrigation can be sunk in nearly all parts of the rice country. The whole of this section is underlain with strata of unconsolidated materials, clay, sand, and gravel, deposited when the region was part of the floor of the Gulf of Mexico, and water is pumped from the sand and gravel beds. In some localities several strata of water-bearing materials are found, but in a few places these are so thin and are composed of such fine sand that but little water can be secured from them. Abundant supplies of water are usually to be found, however.

Pumping from wells is, as a rule, slightly more expensive than pumping from streams on account of the increased lift, but when the rainfall is abundant and favorably distributed not so much pumping is necessary, and well owners have an advantage over irrigators dependent on canal water, which must be paid for, whether much water

is used or not. During dry seasons, however, farmers on canals who get all the water they need have the advantage, because then the wells have to be pumped much of the time. In some wells along the Gulf coast the water stands near the surface of the ground or overflows. Back from the coast the ground surface is sometimes 35 or 40 feet above the water level. In Arkansas the depth of the water level varies from 25 to 60 feet.

POSSIBILITIES IN OTHER METHODS OF OBTAINING WATER.

So-called "providence" methods of growing rice are not usually to be depended upon, but nature will frequently supply part or all of the water needed at small expense. Natural precipitation should not be expected to deliver all of the water needed. However, lest the profits from one crop be offset by losses as large the following year, a reliable water supply should be available for irrigation should the rainfall prove insufficient. The necessity for pumping may often be relieved by planting the rice in low places where water will flow in from surrounding higher land during rains, by storing rain water in reservoirs on higher land, from which it may be allowed to flow down as needed, or by damming up and diverting to the field a small natural stream or water flowing in roadside ditches after rains or when other rice fields are being drained. The extension of field levees out over surrounding land to divert the rainfall to the field; the pumping of water to rice on higher land from a reservoir built in a low place; or even the planting of rice on land that is under water all or nearly all the time, or where water is backed up by tides or overflowed from the swamps and streams, often will serve the same purpose. These methods, which generally can be most easily practiced in thinly settled localities where the irrigation works will not interfere with the operations of neighboring farmers, will very often reduce the amount of water which must be pumped, and consequently will lower the cost of irrigation.

PREPARING FOR IRRIGATION.

After a reliable supply of water has been secured a lateral or small canal must be built to convey the water to the field. A lateral consists of two parallel levees built as high as necessary and 10 to 50 feet apart, depending upon the amount of water required to irrigate the farm. The water must be brought to the highest point of the field. It is most easily distributed if the lateral extends part way down the side of the field past the ends of most of the cuts so that the water may be applied to any cut desired. If the cuts are very long, the lateral should be extended down the slope across the cuts through the center of the field. In this way the water can be applied to the land

most easily. If the source of water is near the field, little or no lateral construction will be necessary.

A large field levee 12 inches or more in height is built around the field to prevent the escape of water. Other levees are built on the field following its contours, to hold the water on the land, a levee being built for every drop of 0.2, 0.3, or 0.4 foot as seems advisable. The field is thus divided into irregularly shaped cuts, depending in size and shape upon the slope of the ground, each cut inclosing a plat of nearly level ground.

An old form of field levee having a base about 5 feet wide and side slopes of 2 horizontal to 1 vertical is quite generally used, although these high, narrow levees act as a barrier to the passage of farm machinery and necessitate the separate cultivation of each cut. They often are covered with unsightly growths of weeds and grass.

Numerous advantages favor wide levees built on bases at least 10 feet wide, and with side slopes gentle enough so that teams can work over and rice be grown on them. These are not much more expensive to build, but do away with much of the annoyance of weeds and grass, and allow the field work to be done much more easily. During harvest they offer dry places on which much of the rice can be shocked. Wide levees are most frequently found on fields which have been brought under cultivation during late years, notably in Arkansas, although some are to be found along the Gulf coast.

LOCATION OF FIELD LEVEES.

Much care is necessary in the location of field levees, since their careless placing is liable to result in uneven flooding when irrigation is begun. Levees usually are permanent, hence their correct location at the start will obviate much trouble and expense so long as the field is irrigated. Only a competent surveyor or a farmer with some experience in using an engineer's level should be engaged to lay out the levees, and he should be given plenty of time to do the work properly. The surveyor will need an assistant to carry the rod. This helper should be a rapid walker and have good judgment in estimating the lay of the land. Level readings at points short distances apart will be necessary so that needless crookedness in the levees may be avoided.

In a large field where the surveyor has to change the position of his instrument to avoid errors, he should establish a system of stakes so that at least one of them will be within reading distance from any part of the field. Levels should be taken on all the stakes to secure the relative elevation of each and should be checked back to the starting point. The level itself should be in good adjustment and sights over 800 feet long should be avoided. The form of the levee and the drop

to be given having been decided upon, the rodman should be sent to the highest part of the field for several readings to show the average elevation of the land. The target should be set on a level with the horizontal wire of the instrument, then raised as high as the drop between the levees is to be, and clamped into place. The rodman then goes to lower ground, holding the rod on the ground frequently so that the surveyor may take readings until the horizontal wire again intersects the target. He then goes over the field giving frequent readings, say every 30 paces, until the points of equal elevation are found. When the surveyor is taking a reading, the rodman should hold the rod in a vertical position. He should choose a point on which to hold the rod the elevation of which is as near as possible to the mean elevation of the ground near which he stands.

A team and plow (preferably a riding plow) should follow the rodman to mark the position of the levee as soon as it is located. Much time can be saved by using another helper to occupy the last point located until the team reaches that point. A boy may be used for this work. This enables the rodman to move on as soon as a point is located. In building levees on a field the furrows must be followed carefully. If the turns are very short or the furrows zigzag, they may be straightened, but a gradual curve should be followed absolutely. Often the improper location of levees is due to the farmer's neglect to follow the furrows, rather than to mistakes on the part of the surveyor.

Field levees should make no sharp turns unless the ground is very uneven, and should be as nearly parallel as possible. Unless the ground makes a drop too steep to permit irrigation or an obstruction interferes, two contour levees should never meet.

BUILDING FIELD LEVEES.

New field levees should be built and all old field levees should be reworked in the winter, when work is slack and the soil is wet. At that time the necessary care may be given to their construction and the levees will be more compact than those made in the late spring or early summer, on account of the winter rains. Levees built in the winter have the further advantage of longer time in which to settle before being used.

In building field levees the ground should be plowed and disked, so that a proper union of the old and new dirt may be brought about by the time the levee is completed. Any large plow may be used. Three or four rounds are plowed, depending upon the size of the plow, the earth being thrown to the levee from both sides. If a large disk plow is used and the team is driven at a fast walk for the last

round or two, the earth can be thrown well toward the center of the levee. A rolling coulter should be used with the moldboard plows, because it leaves a square bank, against which the "push" can slide without leaving the furrow. After the center of the levee has been built by plowing, additional furrows are plowed and shoved on the top and sides of the first ones with a wooden "push," until enough dirt has been heaped up to make the levee the desired size and shape.

A "push" (fig. 1) consists of two heavy planks set on edge with one set of ends spiked together and the other ends spread out so as to form a figure "A" when the braces are in place. Sometimes the parts where the friction is the greatest are faced with metal. They are made of various sizes and shapes, depending upon the size of the levee to be made and the strength of the team, but should be long enough to move the dirt easily and wide enough at the rear to push it as far as is required.

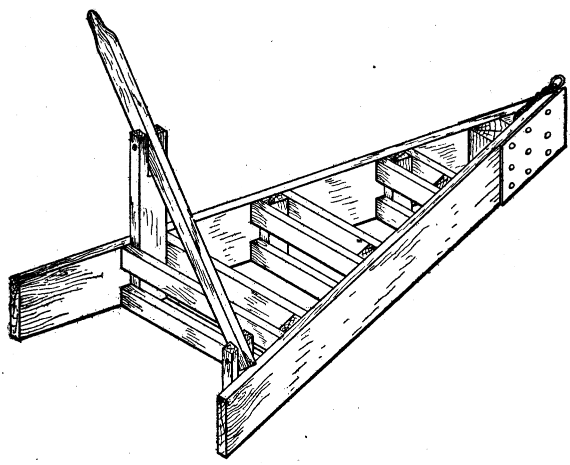

FIG. 1.—Push for building levees.

One side may be made shorter than the other, the shorter side being used to push the earth when it is to be moved a short distance and the long side when the desired distance is greater. A lever with one end fastened to the rear end of the levee side of the push and its center supported from the land side in a horizontal position, crosswise to the furrow, is used to regulate the amount of earth handled and to keep the push in place. In case the push is to be used to shove dirt with either side this horizontal regulating lever must be made so that it may be changed from one side to the other. Sometimes a vertical lever, 5 feet long, used to regulate the push, is fastened to the rear cross braces. A chain passes from a large clevis in the sharp end, or top of the "A," to the team. Sometimes it passes through the clevis and is bolted to the sides of the push. The clevis should be placed just high enough in the heavy wedge of timber generally spiked in the sharp angle formed by the sides of the push, and the chain should be of such length as to cause the sharp end of the push to just drag in the bottom of the furrow and not be lifted into the air.

The sides of some pushes are not vertical, but slope from top to bottom at an angle of 1 horizontal to 3 vertical. When the levee side of the push is elevated on the levee the two sides will be vertical. The land side thus runs straight up in the furrow and not on a slope. The side thrust of the dirt which is being moved prevents the push from leaving the furrow easily. The levee side of the push stands vertical and does not cut under and carry a mass of earth along with it, but allows the earth to roll ahead and slide up the slope. Some pushes are made with a hinge at the front, and the braces are properly adjusted so that the two sides may be swung from or toward each other as desired, being then held in place by pins passing through one of a series of holes in the braces. The horizontal regulating lever for this push is fastened to the rear end of the levee side, but just slides in a notch on the land side so that it does not interfere with the adjustment of the width. The chief advantage which this push possesses is that it may be adjusted to handle dirt at different distances from the levee. Pushes are frequently made with the sides 12 and 13 feet long and 4½ feet wide.

USING A PUSH.

When the push is in use the team is driven along the side of the levee so that the sharp end of the implement follows the last furrow plowed. One side slides in this furrow while the other crowds the loose earth up the levee. Eight mules, with two drivers and a man to tend the push, generally are required to do good work, although smaller pushes, requiring fewer animals, are used when mules are scarce.

When possible, the teams should be worked abreast. In this way the distance back to the push is shortened, one team does not interfere with the other, and there is less tendency for the push to cut out of the furrow when going around a bend. The evener used should be long enough and strong enough so that four large mules may work on each end, the animals in each team then being driven abreast and unattached to the other four. When the push is about to run out of the furrow a swinging of either half or all of the 8-mule team the other way will keep it in place. The man who regulates the push presses down or lifts up the lever, as the push takes too much or too little dirt. This process of plowing and pushing the dirt into the levee is continued until an embankment of the proper shape and size is secured. If several furrows are plowed and pushed in to fill the ditches from which the dirt was removed to build the levee, berms may be built on the side of the levee and the ditches be made shallow and moved from the levee. This will make the side slopes much more gradual and will enable teams to work over the levees. Field levees

should be built at least one-third higher than the level of the water they are to hold, thus permitting rain water to be held on the field and allowing for washing, settling, and for irregularities in the levees. Levees usually appear higher than they really are, and it is well to build them up 12 inches or higher. A farmer may not be able to complete the building of the wide form of levees on his field the first year, but in that case he should aim to widen his levees each year until the proper shape is secured.

Water should not be held deep on the upper side of the levee until the latter has had time enough to thoroughly settle or to gradually become soaked. In sections where the hardpan is some distance below the surface, or where there is no hardpan at all, but merely a closely formed clay, which, when wet, will not support animals, levees have to be built when the ground is dry.

Field levees should be made of good size. The cost of maintaining poor levees is high because they wear down quite rapidly. Poorly constructed levees permit considerable loss of water. It is cheaper to put dirt in a levee with a team and machine before flooding time than with a shovel after the ground is covered with water.

Field levees often are built with a levee plow or with an ordinary road grader. Sometimes only a large disk plow is used. The levee plow is made in various sizes and shapes and consists of a large, strong plow with a long, extended land side and a long steel scraper board, one end of which is welded or fastened by a bolt to the end of the moldboard of the plow. The scraper board is held in position by strong braces, and if the board is fastened by a bolt, the braces are made adjustable, allowing the board to be so regulated that the dirt is moved from 2½ to 6 feet and piled 1½ feet high or more, depending upon the size of the machine.

COST OF FIELD LEVEES.

The cost of building field levees varies with different kinds of soil, the cost of labor, and the number, shape, and size of the levees. The cost of the surveying is variable, depending upon conditions. Fifty or sixty cents an acre is considered the maximum, and 20 cents will sometimes be enough. In one instance, narrow levees were built on 500 acres of river land where the soil was easily worked and the levees were long and close together. The cost per acre was $1.15, or 50 cents for surveying and 65 cents for pushing the levees. The cost of building levees varies from 20 cents per acre, when the land is level and only a few small levees are needed, to $2.50 per acre, where many high levees are built. The yearly cost of repairing levees varies from 5 to 50 cents per acre. Large, high levees cost $12 to $25 per mile. On an average the cost of field levees and the laterals is about $1.50 per acre.

GATES.

On heavy clay soils there is no need of measures to prevent the washing of large openings in the lateral or field levees, but on loose, sandy, loam soils these are necessary. A board set deep edgewise in the levee where the water is to be admitted, so as to permit the water to flow over it, often serves the purpose. Sometimes a sack placed in the opening will keep the dirt from washing out. A wooden gate consists of a floor and end pieces to hold a sliding shutter which regulates the flow of water. The shutter should be made of loose pieces of 4-inch flooring which can be added to or removed as the water is raised or lowered. Such gates make the handling of water much easier than is the case when the levee must be broken each time that the field needs irrigation.

All gates or openings in the field levees should be placed in the corners made by the intersection of the cross field levees with the outside levees, so that they may be out of the way of teams working on the field. The gates should be set deep in the levees, so that all the water may drain from the ditches, and should be in place early in the season, so that the earth may have time to settle around them before irrigation begins, thus preventing many leaks.

APPLYING THE WATER.

The beneficial effects of fresh water on growing rice are evident in the superior appearance of the rice plants where water first enters a field, and by the large yields frequently secured from the cuts first irrigated. The cost of pumping usually is too high to justify frequent drainage and the application of fresh water to the land, but some of the desirable results which follow irrigation with fresh water may be obtained by causing the water to flow in at one end of a cut and out at the other, thus flowing the whole length of each cut. By this circulation fresh water is brought up to the plants and a more even temperature is kept, scum, vegetable matter, and insects also being done away with to a considerable degree. The stale water will thus be pushed down to the low side of the field where it will be the first to escape when the field is drained or overflows during rains.

In the Atlantic coast fields rice is generally planted in rows 15 inches apart, so that it can be cultivated. As soon as the seed is planted the field is generally flooded to cause sprouting, this being called the "sprout" flooding. The water is allowed to remain on the land 6 to 12 inches deep until little white sprouts one-third inch long have pushed through their hulls. The water is then completely drained from the soil in order that the rice may not rot. As soon as the small, sharp-pointed, single leaves of the rice plants appear, the field is given the second flooding. This is called the "point" or

"stretch" flow, its purpose being to force the growth of the rice plants ahead of the weeds and grass and to kill the latter.

After the rice is 6 inches tall the water is generally lowered until it is about 4 inches deep on the land, and is held at that depth 13 to 30 days. The old water is drained off and fresh water is applied every week or ten days. The "stretch" flow is followed by a period of dry growth which lasts 40 to 50 days, during which a short flooding is sometimes applied in dry seasons. At this stage the rice is cultivated with horse plows two or three times and is hoed once or twice by hand to kill all weeds, grass, and red rice, and to stir the soil thoroughly. When the plants have begun to joint the "harvest" flow is applied. The field is flooded 4 or 5 inches deep and the water is allowed to remain until just before the rice is harvested. The rice is cut by hand with sickles, shocked, and thrashed with improved machines.

The average length of the irrigation season in the rice sections of Arkansas, Louisiana, and Texas, extending from the time of the first application of water until it is removed to permit harvest, is about 86 days. Under favorable weather conditions the season may be reduced to 70 days, but early rice, which matures much more slowly than that planted later, may require as many as 120 days of irrigation. In a general way the times of irrigation and the amount of water to be applied depend wholly upon the various stages of the growth of the rice plants, but a number of other factors must also be considered, and these may materially modify the usual irrigation program. Methods of cultivation of rice have been described in other publications of this department, and these should be consulted for information regarding the several periods of development experienced by the rice plant and its demands for water while growth is being made.

Similarly, the judicious and timely application or removal of irrigation water may be made a most effective means of warfare against numerous diseases peculiar to the rice plant and against the insects[1] and other pests which harass it.

[1] Considerable injury is done to the rice plants by a small white worm about one-fourth to one-half inch long. This is called the rice root maggot and is the larva of the rice water weevil. A discussion of the habits of this insect and of its control by irrigation will be found in U. S. Dept. Agr., Bu. Ent. Cir. 152.

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